# Unified Substrate Theory: SIT–DHP Framework

A Cross-Domain Information-Processing Model of Physical, Cognitive, and Social Systems

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**Abstract**

This preprint presents a unified systems framework in which physical, cognitive, and social phenomena emerge from the behaviour of a finite-capacity information-processing substrate. The model, termed *Substrate Information Topology* (SIT), is grounded in a single underlying principle: the *Fundamental Information Tendency* (FIT).

FIT is defined as the universal tendency of information-bearing systems to minimise lag by redistributing load, increasing capacity, or improving alignment. This tendency is expressed mathematically by a Lag Equation relating information load, substrate capacity, and refresh rate.

Empirical constraints from galaxy cluster mergers (e.g., Bullet Cluster, El Gordo, Abell 520, Abell 2744) suggest a consistent saturation boundary at $\omega \sim 10^{10}$, above which the substrate enters a nonlinear regime characterised by lossy compression and baryonic–gravitational decoupling.

The same structural threshold appears in cognitive overload and social instability, motivating the integration of SIT with the Dynamic Harm Principle (DHP), a systems-ethics model describing human-node stability. A perceptual distortion parameter $\varepsilon$ is introduced to distinguish physical lag from perceived lag.

The entire framework is released under CC0 to enable unrestricted scientific scrutiny and derivative work.

# 1 Foundations

## 1.1 Fundamental Information Tendency (FIT)

**Definition.** FIT is the universal tendency of information-processing systems to minimise lag by:

- reducing information load,
- increasing effective capacity, or
- improving alignment between structure and task.

Systems evolve along gradients that reduce a lag functional $L$, subject to local constraints. FIT is the root principle of the framework. All higher-level structures—SIT, RFIT, DHP—are specific instantiations of FIT in different domains.

## 1.2 Lag Equation

The core invariant is:

$$L = \frac{\omega}{\kappa \cdot \alpha}$$

where:

- $L$: lag / latency,
- $\omega$: information load (entropy, density, velocity dispersion),
- $\kappa$: substrate capacity (bandwidth of the vacuum),
- $\alpha$: refresh rate (sampling frequency of the substrate).

This is structurally equivalent to the general FIT form:

$$L = \frac{W}{K \cdot a}$$

with the mapping $W \leftrightarrow \omega$, $K \leftrightarrow \kappa$, $a \leftrightarrow \alpha$.

# 2 Substrate Information Topology (SIT)

SIT models the universe as a finite-capacity information-processing substrate. The substrate:

- carries information about matter and fields,

- has bounded capacity $\kappa$,
- updates at a finite refresh rate $\alpha$,
- exhibits lag $L$ when $\omega$ approaches or exceeds $\kappa \cdot \alpha$.

Lag manifests observationally as spatial offsets, curvature, delayed relaxation, or apparent nonlocality.

# 3 Saturation and the $10^{10}$ Threshold

Across high-energy astrophysical systems, a consistent overload boundary emerges:

$$\omega_{\text{crit}} \approx 10^{10}.$$

## 3.1 Linear Region ($\omega < \omega_{\text{crit}}$)

- Coherent multi-body interaction,
- Real-time rendering ($L \approx 0$),
- Smooth gradients,
- Stable structures.

## 3.2 Nonlinear Region ($\omega \geq \omega_{\text{crit}}$)

- Effective degradation of $\kappa$,
- Nonlinear, congested regime,
- Lossy compression,
- Baryonic lag relative to gravitational core,
- Spatial offsets (e.g., Bullet Cluster).

# 4 Lossy Compression Model

When $\omega > \kappa \cdot \alpha$, the substrate prioritises:

1. low-entropy gravitational structure,

2. high-entropy baryonic detail at reduced fidelity.

This yields:

- gravitational coherence,
- baryonic displacement,
- apparent dark-matter-like behaviour,
- no requirement for new particles.

# 5 Recovery Dynamics

After saturation, systems relax toward equilibrium.

$$t_{\text{relax}} \sim 10^{15} \text{ s}$$

Thermal limit:

$$T_{\max} \sim 10^{8} \text{ K}.$$

Above $T_{\max}$, immediate decoupling occurs.

# 6 Perceptual Distortion Parameter $\varepsilon$

Human observers experience:

$$L_{\text{perceived}} = \varepsilon \cdot L.$$

- $\varepsilon > 1$: overestimation (panic, distrust),
- $\varepsilon < 1$: underestimation (complacency),
- $\varepsilon = 1$: accurate perception.

# 7 Dynamic Harm Principle (DHP)

A human node enters harm state when:

$$\omega_{\text{internal}} \geq 10^{10}.$$

This corresponds to cognitive overload, trauma, or loss of agency.

### 7.1 Survival Floor

To maintain stability:

- energy,
- food,
- shelter,
- safety,
- social coherence

must be guaranteed.

## 8 Cross-Domain Equivalence

| Domain | Load | Capacity | Refresh | Lag |
|---|---|---|---|---|
| Physics | entropy, density | vacuum bandwidth | sampling rate | curvature |
| Cognition | stress, complexity | working memory | attention | emotion |
| Society | demand, conflict | institutions | coordination | instability |
| Engineering | traffic, load | throughput | clock speed | latency |

## 9 Falsifiability

The framework is falsified if:

1. systems exceed $\omega \gg 10^{10}$ without nonlinear collapse,
2. baryonic–gravitational separation occurs without $\kappa$ degradation,
3. cognitive systems exceed threshold without overload,
4. social systems exceed threshold without instability,
5. systems evolve toward higher lag without external constraints.

# 10 Conclusion

The SIT–DHP framework, grounded in the Fundamental Information Tendency (FIT), proposes that physical, cognitive, and social systems share a common information-processing structure governed by the Lag Equation. Substrate saturation, lossy compression, and recovery dynamics provide a unified explanation for phenomena ranging from galaxy cluster mergers to cognitive overload and social collapse.

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